Extreme Habitats III: Arid Habitats & Polar Regions

FISH 310

Today's Roadmap

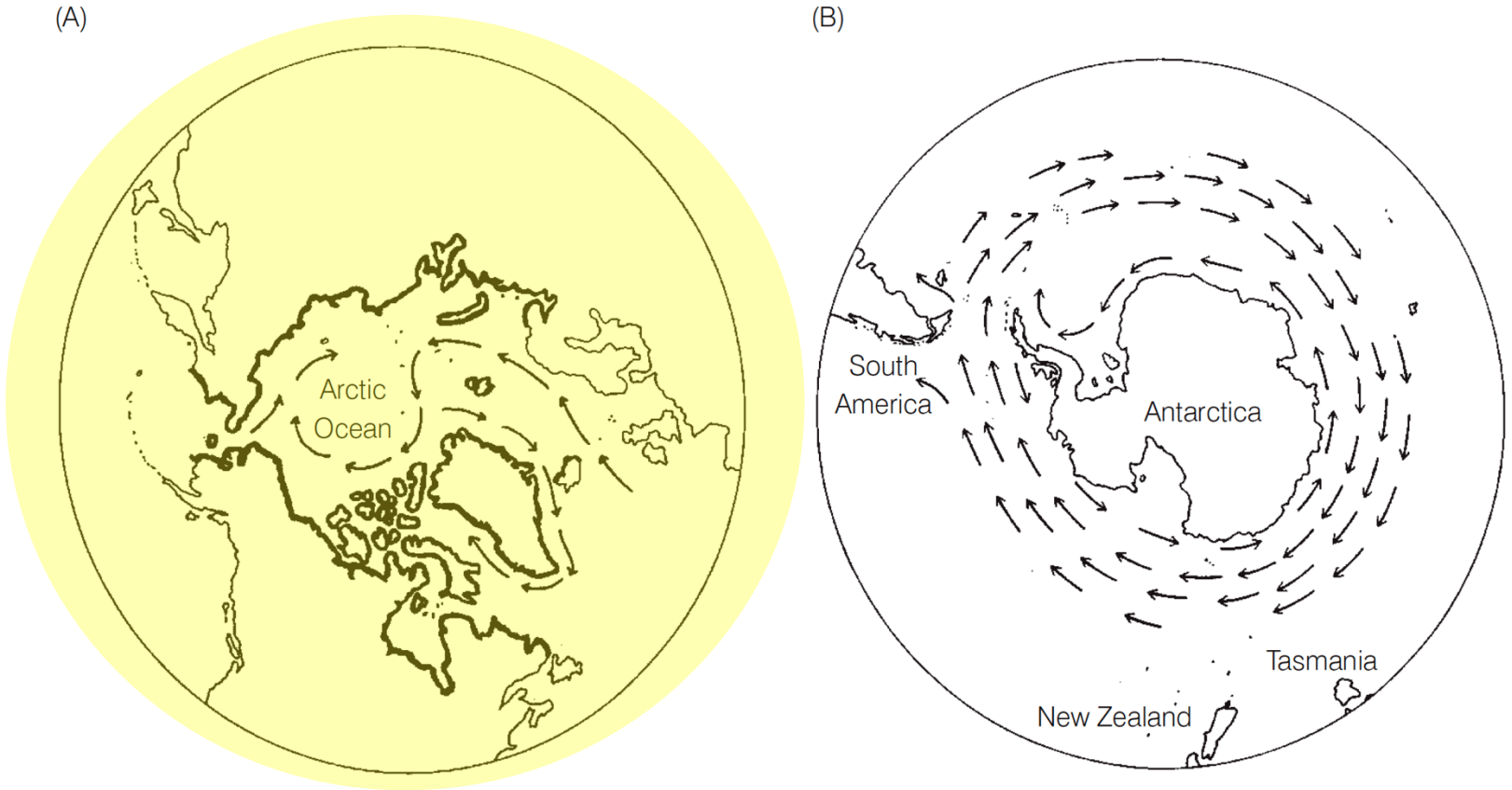
1. Polar Regions
    1. What defines polar regions and how are the Arctic and Antarctic regions different?
    2. Antarctic fishes and their adaptations
    3. Arctic fishes and their adaptations
2. Arid Regions
    1. Challenges of arid habitats
    2. Adaptations of arid habitat fishes
    3. Arid fishes by continent

Geography of the Polar Regions

- > 60º latitude, cold water temperatures, short growing seasons
- **Arctic = frozen ocean surrounded by land**
  - **Lakes & rivers w/limited fish fauna (~55 spp. in Canadian arctic) b/c water stays liquid below ~3 m; strong behavioral adaptations to changing light levels**

Figure 18.8

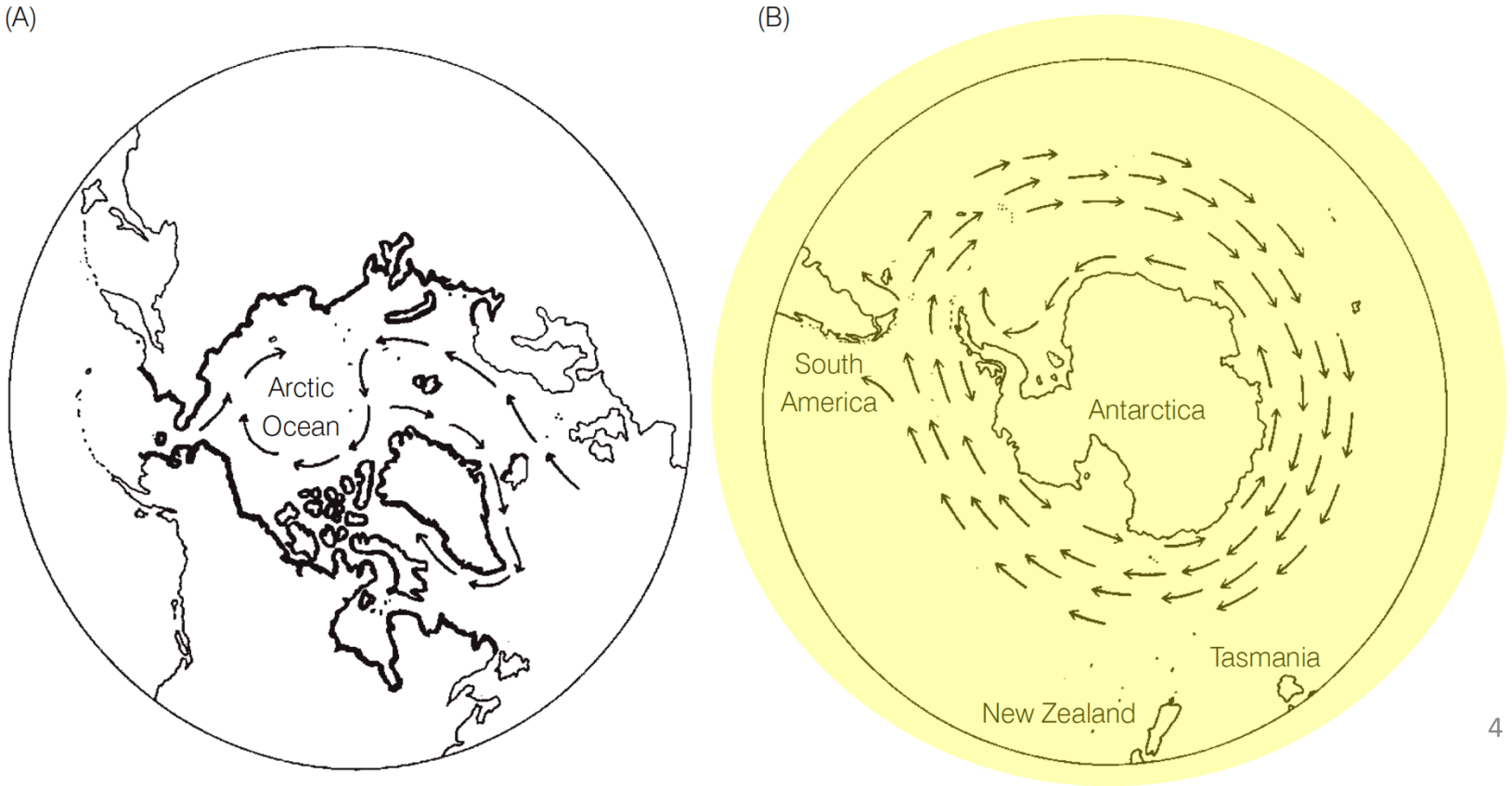
North and south polar regions. General oceanic circulation patterns are shown by arrows. (A) The Arctic Ocean centers on the North Pole; the southern limits of the region are indicated by the dark continental borders. (B) The Southern Ocean surrounds Antarctica. Some of the islands on the periphery of the south polar region are indicated.



Geography of the Polar Regions

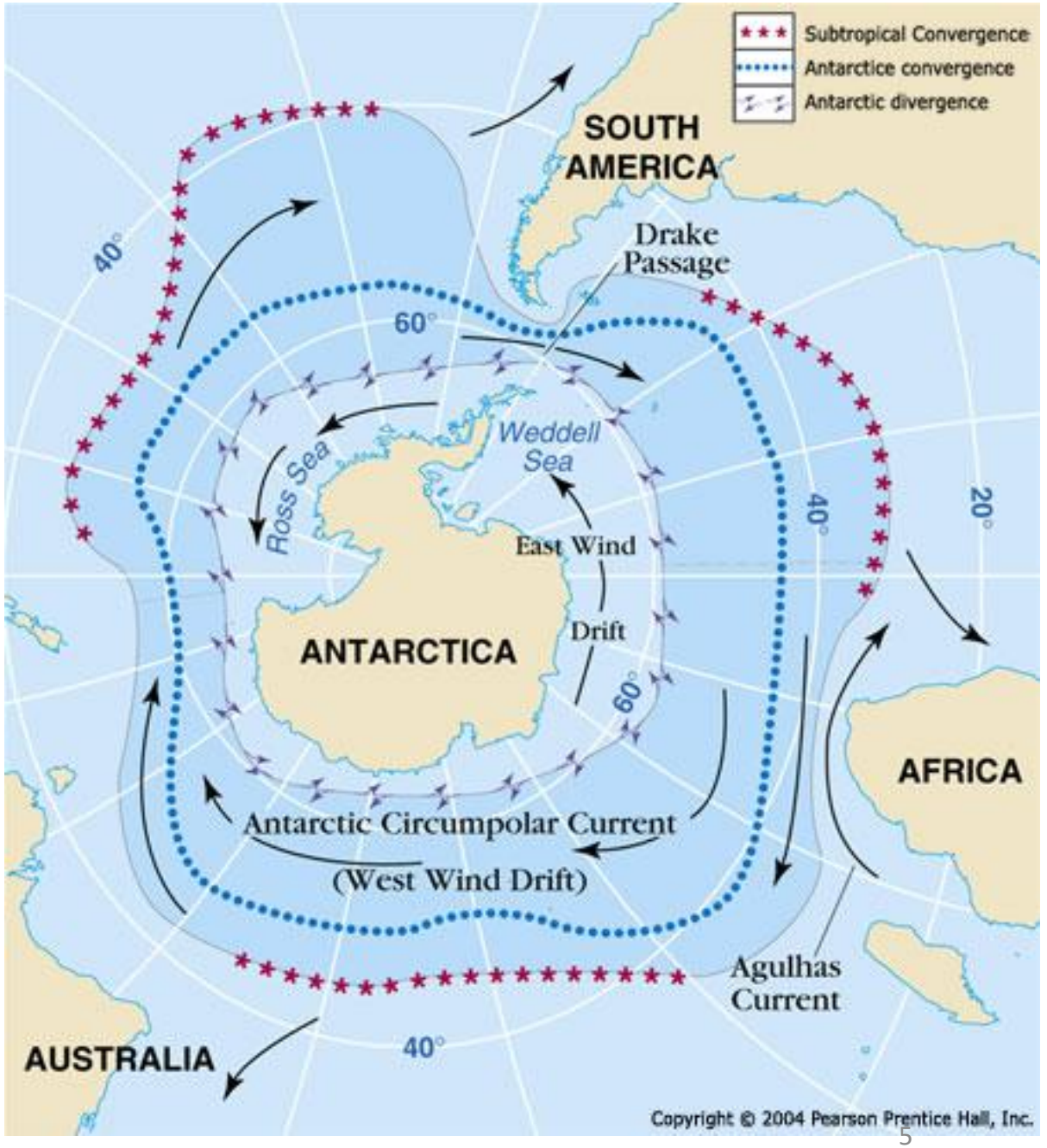
- > 60º latitude, cold water temperatures, short growing seasons
- **Antarctic = frozen continent surrounded by ocean**
  - **No freshwater fishes; water bodies have permanent ice even to the bottom during winter**

Figure 18.8
North and south polar regions. General oceanic circulation patterns are shown by arrows. (A) The Arctic Ocean centers on the North Pole; the southern limits of the region are indicated by the dark continental borders. (B) The Southern Ocean surrounds Antarctica. Some of the islands on the periphery of the south polar region are indicated.

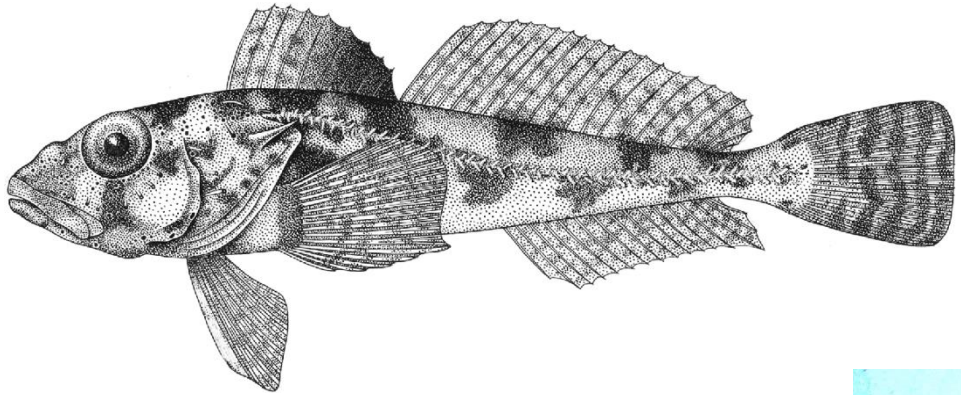


Antarctic environment

- **Antarctic Convergence** at 50–60°S: distance, depth, and thermal barrier to interchange between cold-adapted Antarctic species & warm-adapted species
- Antarctic region separated from Australia during Early Cenozoic Era (20–25 mya)

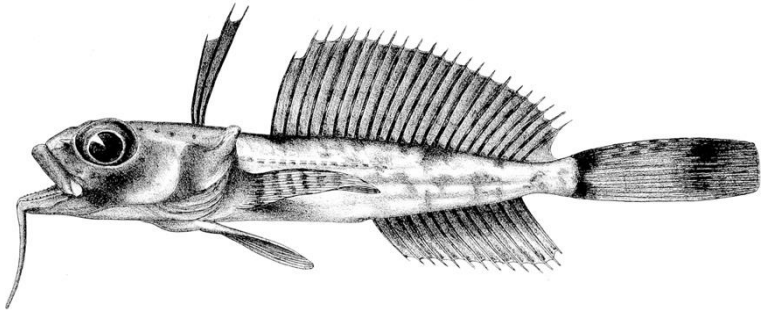


Antarctic Fish Diversity



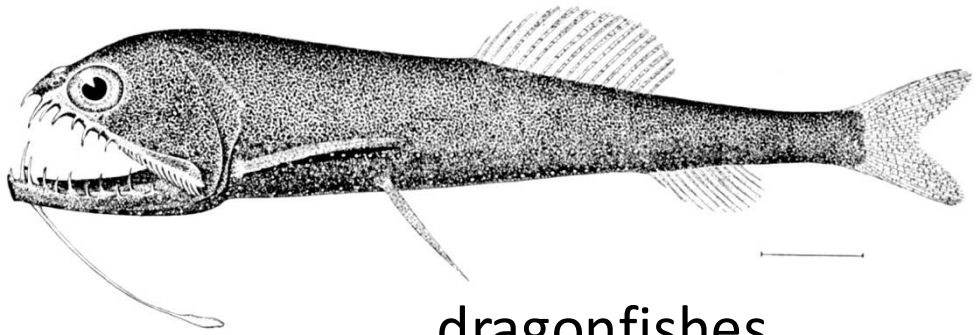
notothenioid thornfishes
Bovichthyidae

crocodile icefishes
Channichthyidae



plunderfishes
Artedidraconidae

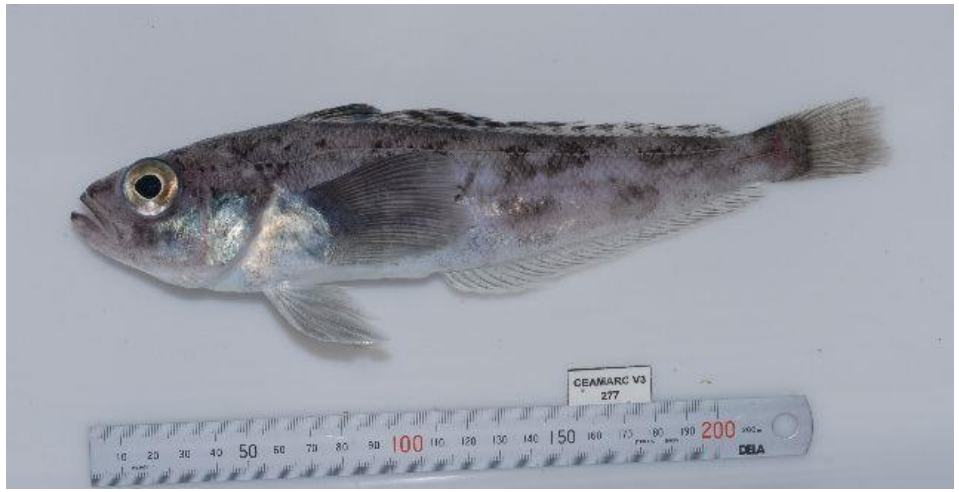
cod icefishes
Nototheniidae



dragonfishes
Stomiidae

Suborder Notothenioidei (125 spp)

Bovichtidae
temperate icefishes



Notothenioidae
cod icefishes

Channichthyidae
crocodile icefishes

Suborder Notothenioidei (125 spp)

- ½ of notothenioids are benthic in <1000 m of water, pelagic larvae
- No gas bladders, dark coloration
- Use sponges for refuge

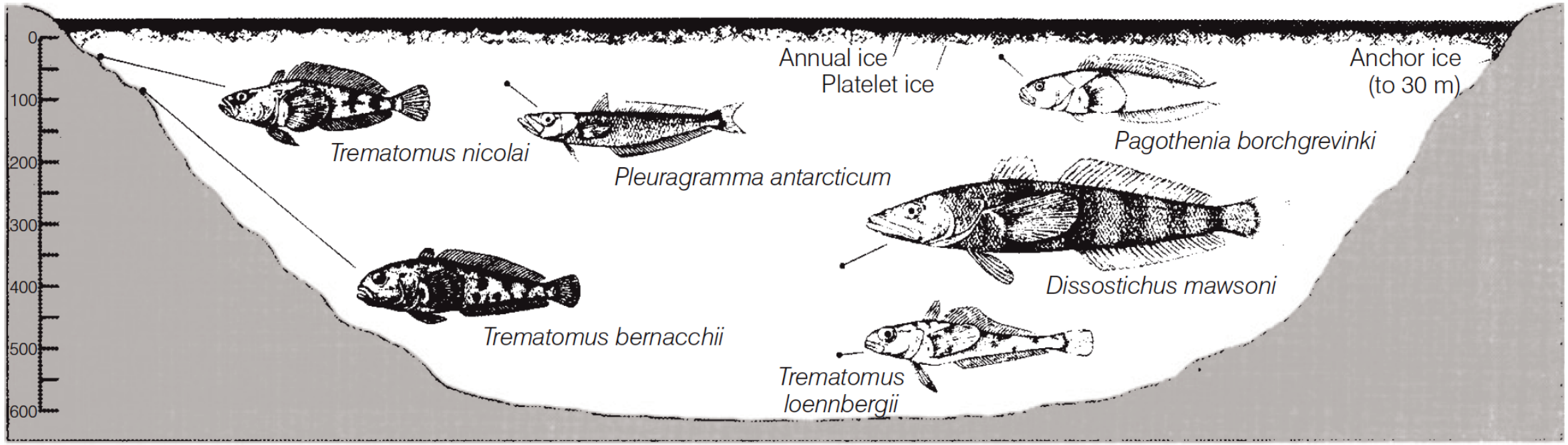


Figure 18.9

Body form and habitat types of common Antarctic notothenid fishes. The dots show the preferred depths and habitats. From Eastman (1993), after Eastman and DeVries (1986), used with permission of Scientific American, Inc., all rights reserved.

Major adaptations of notothenioids:

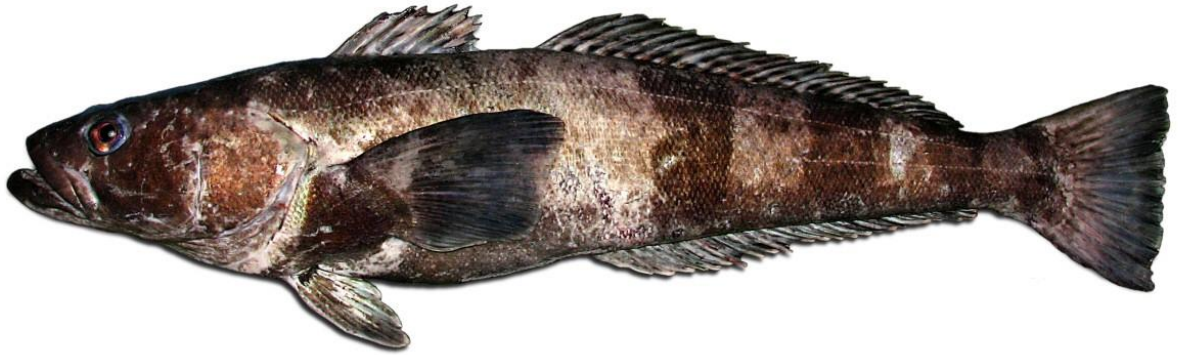
1. Antifreeze compounds in the blood
   - No glomeruli in the kidney (to retain the glycopeptides)
2. Neutral buoyancy

Anchor ice attaches to the bottom (< 30 m) & if a fish contacts it, it will seed ice crystal formation in the fish's blood

Major adaptations of notothenioids:

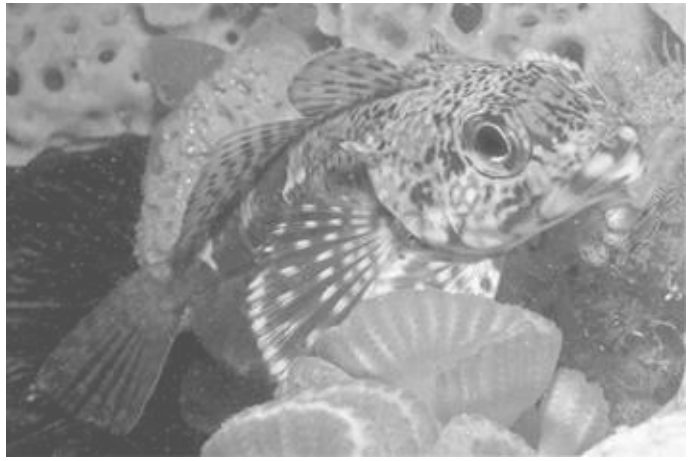
1. Antifreeze compounds in the blood
   - No glomeruli in the kidney (to retain the glycopeptides)
2. Neutral buoyancy
   - Pelagic fishes, lack g.b., but with reduced ossification of the skeleton & lipid deposits throughout the body

Pleuragramma antarcticum
Cod Icefish

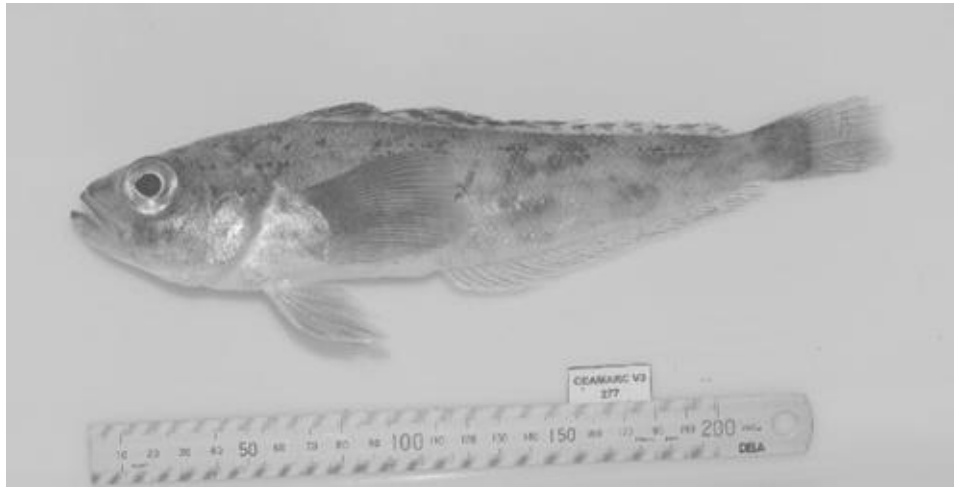


Dissostichus mawsoni
Antarctic Toothfish

Suborder Notothenioidei (125 spp)



Bovichtidae
temperate icefishes



Nototheniidae
cod icefishes

Channichthyidae
crocodile icefishes

”Bloodless” or “white blooded” fishes because they have no myoglobin in their muscles!

Arctic Fish Diversity

sculpins
Cottidae

wolffishes
Anarhichadidae

salmonids (char)
Salmonidae

flatfishes
Pleuronectiformes

cods
Gadidae

Arctic environment & adaptations

- **Convergence of traits with Antarctic fishes**
- **Greater annual & latitudinal temperature variation** compared w/the Antarctic, results in:
  - Seasonal variation in antifreeze production
  - Greater ability to withstand heat

Arctic Cod
Boreogadus saida

Winter Flounder
Pleuronectes americanus

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Arid Habitats

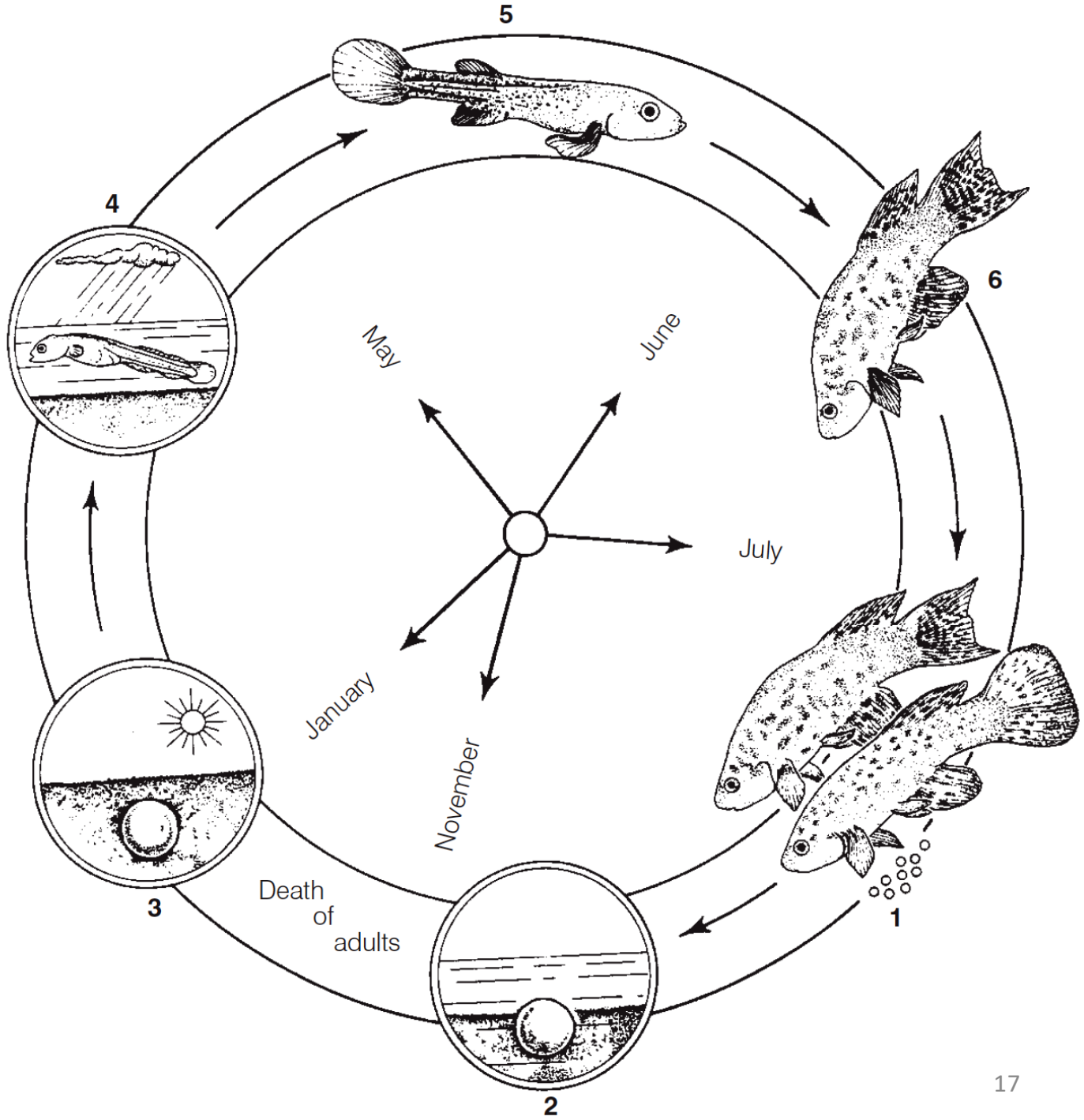
- Deserts = areas that receive < 30 cm annual rainfall, or where "biological potentialities are severely limited by lack of water" (Goodall 1976)
- Fishes must withstand:
  - Higher temperatures
  - Increased concentration of solutes
  - Decreased oxygen tension
  - Increased CO2
  - Intensified predation & competition
  - Flash floods
  - Changing alkalinity

3 general adaptations of fishes in arid regions

1. **Annual life history** involving egg deposition in mud during the wet season, an egg resting period (diapause) during the dry season, death of the adults, and egg hatching when habitats are re-inundated the next year
2. **Accessory respiratory structures** for using atmospheric oxygen (lungs, gill and mouth chambers, cutaneous respiration)
3. **Estivation** (in perennial spp.) where adults pass the dry season in some sort of resting state

Figure 18.10

Life cycle of annual cyprinodontoids, as shown by the Venezuelan *Austrofundulus myersi*: 1, spawning occurs over a protracted period; 2, shelled eggs are deposited in the mud; 3, as water dries up, adults die but eggs remain viable in an arrested developmental stage; 4, with the return of the rains, eggs hatch; 5, larvae and juveniles grow rapidly; 6, maturation occurs after only a month or two, followed by spawning. From Wourms (1972), used with permission.



Cyprinodontiform killifishes & rivulines (Africa)

Annual life history

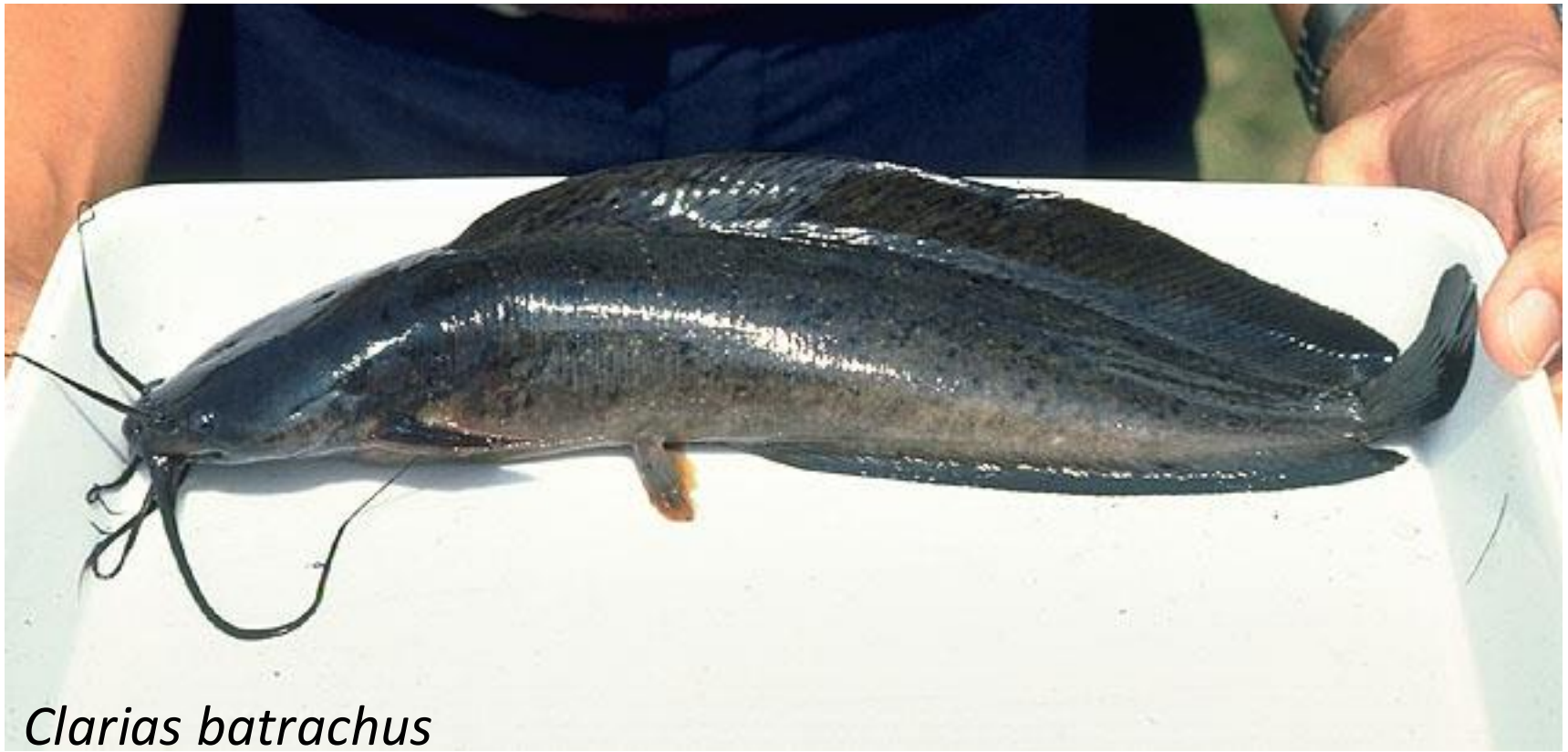
Fundulosoma

Notobranchius

Aphyosemion

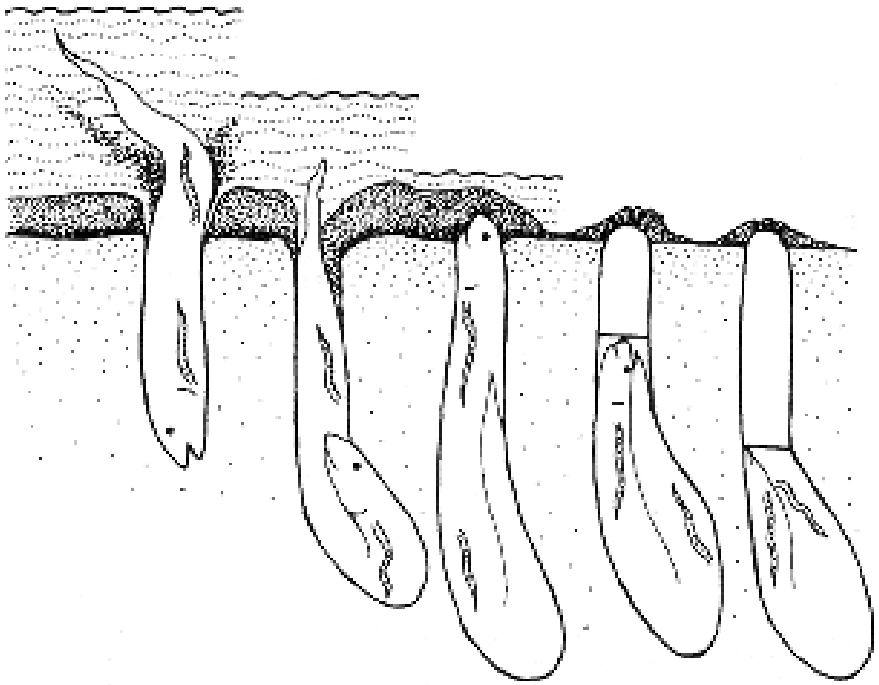
Clariid (walking) catfishes (Africa & Asia)

Capable of 'walking' to a new body of water
suprabranchial organs

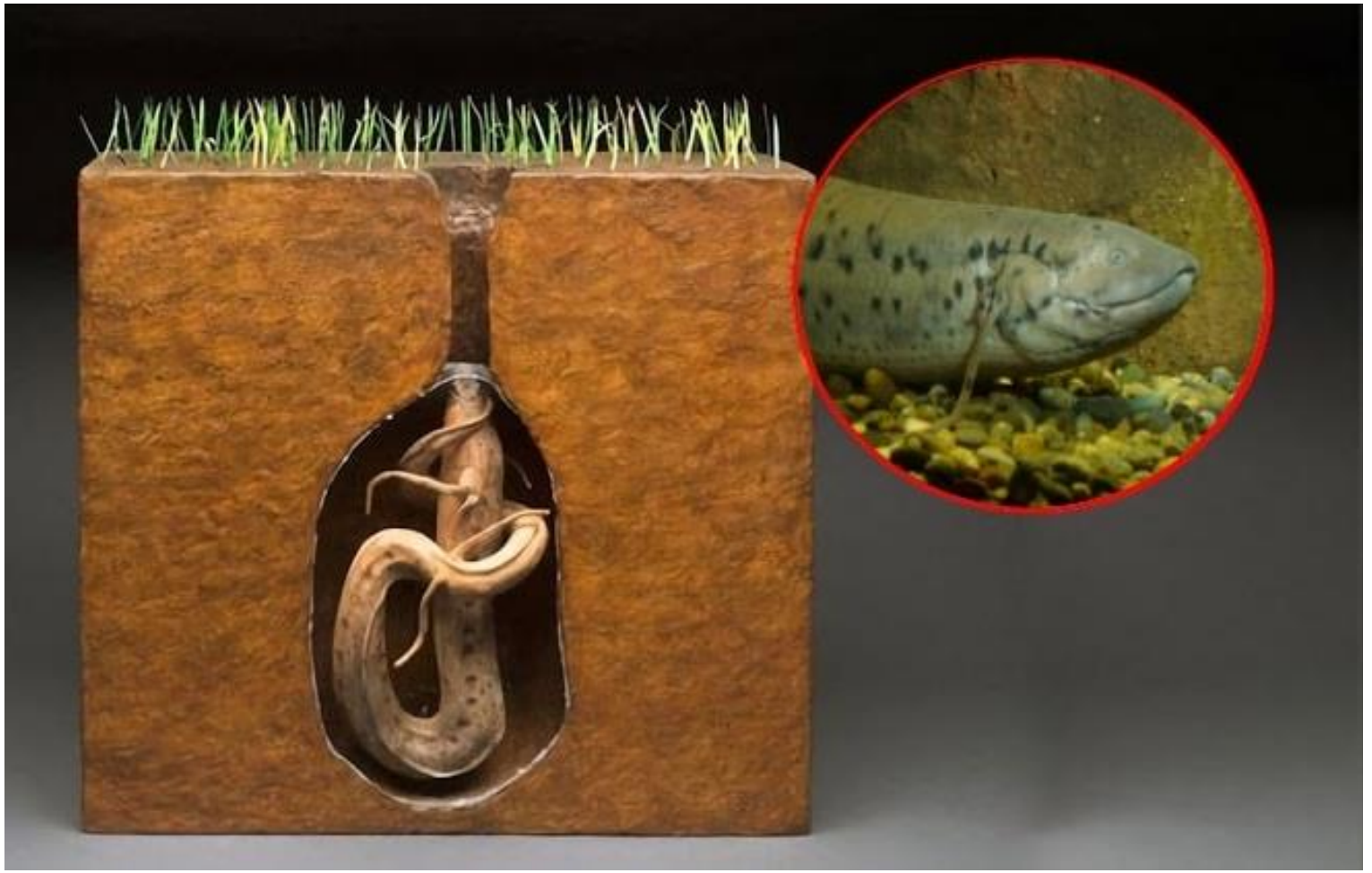


Clarias batrachus

Aestivation in burrows



As the water level falls lungfish burrow into the bottom mud to form a cocoon and aestivate through the dry season.



Adaptations for **deoxygenation** (African swamp spp.)

Take advantage of higher O_2 partial pressure near surface

Killifishes

Mochokid catfishes

Pike Characin

Adaptations for **deoxygenation** (African swamp spp.)

Lungfishes

Lungs

Bichirs

Gill chamber organs

Clariid Catfishes

Adaptations for **deoxygenation** (African swamp spp.)

Labyrinth organs

Anabantids

Pharyngeal diverticula

Snakeheads

Alveolar gas bladders

Featherfin knifefishes

Phractolaemids

Convergent evolution: South American adaptations

- Surface swimmers, such as arawanas and some characids w/**vascularized lips**
- Modified **mouth region** of Electric Eels and swamp eels
- Air-filled **stomachs** in loricariid catfishes
- Vascularized **hindgut** in callichthyid armored catfishes,
- Vascularized **gas bladder** in lungfish, *Arapaima*, and erythrinid trahiras.
- South American species cross small stretches of wet vegetation or mud in an apparent search for new and wetter habitats (e.g., erythrinids such as *Hoplias* and *Hoplerythrinus*, callichthyid catfishes, some rivulines)

Arapaima

Hoplerythrinus

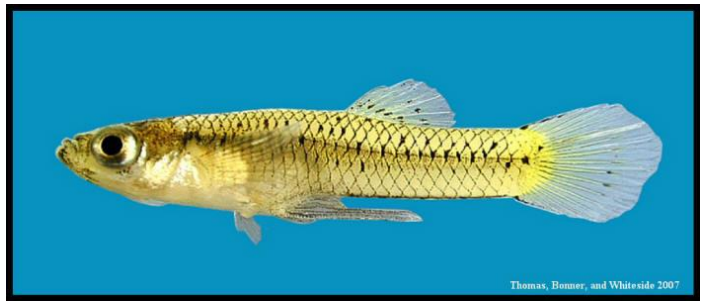
Australian deserts

- Mostly a desert continent, f.w. fish fauna dominated by marine derivatives
- *Lepidogalaxias salamandroides* burrows into the sediment & surrounds self with a mucus coat
  - Avoid producing nitrogenous wastes by metabolizing lipids not proteins, resulting in CO_2 not nitrogen compounds!
- *Chlamydogobius eremius* can survive in...
  - Distilled water to higher salinity than seawater
  - Temperatures from 5-40 º C
  - Oxygen concentration < 1 ppm

North American Deserts

- The Basin and Range Province includes Great Basin, Mojave, Sonoran, and Chihuahuan deserts, constitutes < 10% of the total land area of North America
- A desert for ~12,000 years
- Two major types of desert habitat:
  1. Isolated pools and basins
  2. Intermittent marsh and arroyo habitats along flowing water courses

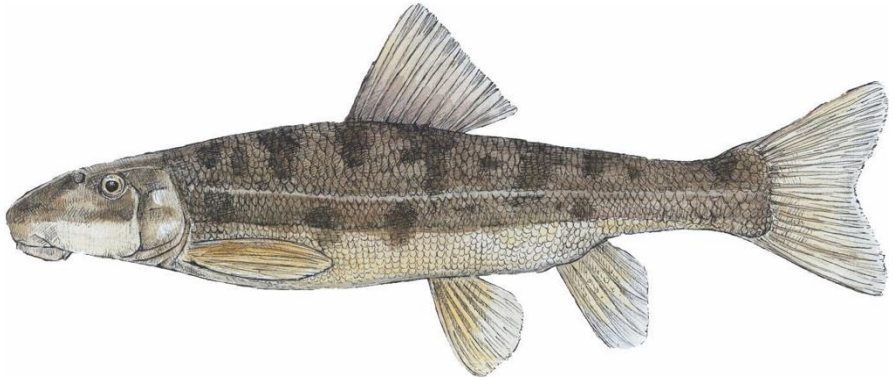
N. American Desert Fish Diversity



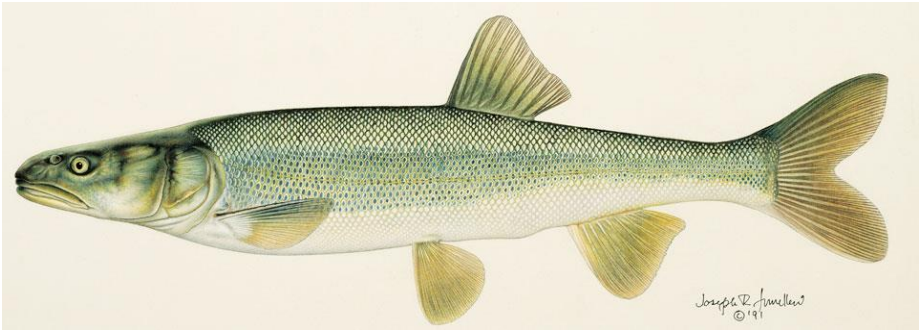
livebearers
Poeciliidae

pupfishes
Cyprinodontidae

trout
Salmonidae



suckers
Catostomidae



minnows
Cyprinidae

Devil's Hole Pupfish, *Cyprinodon diabolis*

- Endangered, 2 cm long
- Lives on an 18 m^2 shelf in a spring basin in the **smallest habitat of any known vertebrate**
- Can survive **0.13 ppm dissolved O2**
- Can tolerate > 100 ppt salinity (up to 3-4x that of seawater)
- Can tolerate freezing water temp's up to 44º C

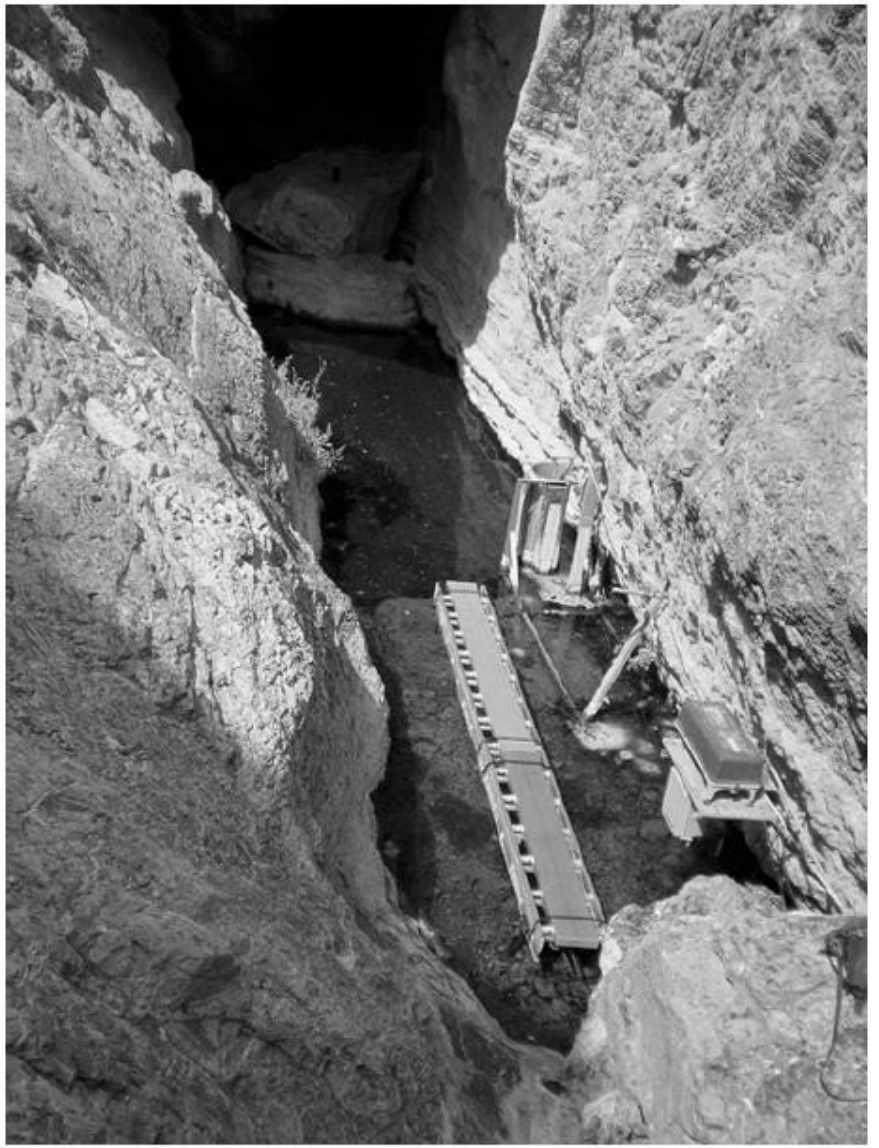


Figure 18.11

Devil's Hole, Nevada, natural home of the Devil's Hole Pupfish, the first fish listed under the US Endangered Species Act. Visible are water-level monitoring equipment and a platform for people to walk on while doing fish counts. Photo by J. Barkstedt, used with permission.